Summary
(A Finite-Difference-Based Reactive Transport Model Assessment of the Effects of Ethanol Biotransformation on the Lengths of Benzene Plumes from Leaking Underground Fuel Tanks)

Groundwater modeling studies used to predict benzene plume behavior in the presence of ethanol have included several simplifying assumptions, including the following: π(1) there will be preferential biodegradation of dissolved ethanol near the release source area, (2) no benzene degradation will occur within this ethanol degradation zone, (3) downgradient from the ethanol degradation zone, there will be a depletion of available electron acceptors that will result in lower benzene degradation rates, and (4) within the downgradient electron acceptor depletion zone, the benzene degradation rate is constant in time and space. These assumptions, if incorrect, would tend to overestimate predicted benzene plume lengths.

A more sophisticated modeling approach that better represents the spatial and temporal transport of electron acceptors is presented in this chapter. This modeling scenario treats the ethanol and benzene source terms as simple injection processes at a point; diffusion-limited partitioning out of a separate phase lens floating on top of the water table is not taken into account.

The modeling results suggest that:

- A four-fold decrease in the mean benzene biotransformation rate brought on as a consequence of ethanol biotransformation, and subsequent electron acceptor depletion, can potentially increase benzene plume lengths by a factor of roughly 2.5.
- This increase in benzene plume length is not inconsistent with the earlier findings using different modeling methodologies (McNab *et al*., 1999), although it is somewhat toward the high end of the estimated plume length extensions explored.

A combination of more sophisticated reactive transport modeling (fully three-dimensional, with considerations of all plausible electron acceptor species) and additional constraints on reaction kinetics could be utilized in a future study to evaluate the plume lengthening phenomenon in more detail, taking into account the following:

- Diffusion of dissolved oxygen across the water table from vadose zone, which would likely act to suppress the increases in benzene plume lengths in many scenarios, since benzene plumes associated with nonaqueous phase liquids (LNAPLs) are likely to harbor the highest concentrations in the upper reaches of an aquifer.
- Dispersion of benzene and electron acceptors in the vertical dimension, both of which will serve to reduce the benzene plume length enhancement effect of ethanol.
- The effects of gas phase equilibria (carbon dioxide and methane) on aqueous phase oxidation-reduction geochemistry.
- The role of mineral phases, specifically Fe- and Mn-oxyhydroxides, in influencing oxidation-reduction geochemistry.